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HOS 1-26 MHV

Reply to 3400 Forest Pest Management
2400 Timber

Date JAN 17 1983

Subject **Program of Measuring Tree Vigor**

To **Forest Supervisors and District Rangers, East Side NF's;
Forest Supervisors and District Rangers, Gifford Pinchot, Mt. Hood,
Rogue River and Umpqua NF's**

Please distribute the enclosed copies to each District Silviculturist. The report contains a revised program for calculating tree vigor of lodgepole pine, ponderosa pine and Douglas-fir. The program was written by T. F. Gregg and R. E. Dolph to be used in a Hewlett Packard 41CV calculator. The program is an expansion of the one we sent to you last year; however, the writeup on the report is the same. At the request of some users, Tom and Bob revised the program to obtain stand averages in the field. They also added a line for recording basal area/acre plot data and obtaining standard deviation values for the grams of wood produced per square meter of foliage and basal area/acre.

If you have any questions about this new version on the tree vigor program, please call us. Also, if you have incorporated new ideas or techniques on this program, we would like to hear from you.

PAUL E. BUFFAM, Director
Forest Pest Management

Enclosure

cc:
Fred Graf, OSDF, Prineville
LeRoy Kline, OSDF, Salem

HOW TO HAZARD RATE LODGEPOLE PINE OR SECOND-GROWTH PONDEROSA PINE STANDS AND DEVELOP MANAGEMENT GUIDELINES TO PREVENT FUTURE MOUNTAIN PINE BEETLE LOSSES[1/]

by

Robert E. Dolph

I. INTRODUCTION

This document describes a system for rating lodgepole and ponderosa pine stands susceptibility to damage by mountain pine beetle. The rating system for lodgepole pine was developed by Waring and Pitman (1980) and Waring et al (1981) and incorporates broad silvicultural management recommendations designed to reduce or prevent future losses from mountain pine beetle. The ponderosa pine system is based on Sartwell and Stevens (1975) and Sartwell and Dolph (1976) and adapted to the Waring/Pitman technique. This system is designed to do two things: (1) rate lodgepole or ponderosa pine stands as to the risk of generating or sustaining an epidemic population of mountain pine beetle (susceptibility), and (2) identify those stands which are in imminent danger of being destroyed by the beetle (imminent hazard). The objective is to develop flexible, yet biologically and silviculturally sound, management systems for use in both pure and mixed lodgepole-ponderosa pine stands, including those containing other conifer species. The broad management options are based on the work of Barrett, 1979; Alexander et al, 1967; Myers, 1961; and Dahms, 1971 and 1973.

This document represents the state-of-the-art for risk-rating stands for mountain pine beetle damage. As advancements are made, they will be incorporated to refine these systems.

II. BACKGROUND

This risk-rating system has its basis in the ability of trees possessing certain measurable characteristics to resist damage from mountain pine beetle attacks. Mountain pine beetles seem to "sense" those stands or trees susceptible to attack. Waring and Pitman (1980) found that tree vigor, as expressed by the amount of stemwood produced per square meter of foliage, could be used to predict susceptibility to mountain pine beetle attack.

Waring states trees producing small quantities of stemwood per square meter of foliage (less than 50 grams) are more susceptible to attack than trees producing large quantities of stemwood (more than 100 grams). Associated with the reduction of stemwood production is a change in the production of monoterpenes, volatile compounds that mountain pine beetles detect.

Reduced stemwood and monoterpene production can be caused by several factors. Trees stressed by shading, nutritional deficiencies, drought, disease, etc. are likely to experience decline in production of stemwood and monoterpenes.

Overstocking is a major cause of reduced tree vigor. In general, tree vigor decreases directly with increasing canopy density. Waring has expressed the canopy in terms as the leaf area index (LAI). He added, "LAI for lodgepole rarely exceeds six layers of leaves" (one layer equals 10,000 square meter of foliage per hectare) (see Appendix A).

1/ Procedures are adopted from Guidelines developed by Swaby and Chetock, Oregon State Department of Forestry (1981).

Collect Stand Data--Suggest prism plot cruising, using a 10 BAF, and establish 15 sample points per stand and record the following:

1. Basal Area (BA) for stocking/ Around Sample Tree =

2. Diameter distribution by 2-inch classes (DBH);

3. At each sample point, select a green dominant host tree nearest plot center:
   a. Take and Record Basal Area
   b~~a~~. Measure d.b.h. to nearest 0.1 inch;
   c~~b~~. Take two increment cores from opposite sides of sample tree;
   d. Measure in centimeters the width of the last completely formed annual ring on each core, calculate average, and record ring in centimeters.

4. Sapwood thickness-like annual ring width can be measured from the two cores and calculate the average OR estimate by assuming for lodgepole pine that about 70% of the total stem basal area is sapwood; for ponderosa pine, assume 90% of the total stem basal area is sapwood (Appendix B).

5. In stands where the beetle is active, it is often desirable to record individual tree condition: Green, Green infested, Redtop, Older Dead, and Nonhost Species for determining percent of stocking in mixed stands. The Stand Examination Plot Card (Form R6 2410) can be used for recording data.

Calculate Tree/Stand Vigor--To facilitate calculating tree vigor, a program is available for handheld calculators HP-67, HP-97, HP-41C and HP-41CV (Appendix C)[2]. For broad tree vigor classifications, graphs have been developed for use in the field, eliminating the need for a calculator. The graphs are based on the assumption that 70% of the stem basal area of lodgepole pine is sapwood (Fig. 1) and 90% for ponderoa pine (Fig. 2).

For estimating stand vigor, compute the mean tree vigor of the 15 dominant trees sampled.

Determine Stand Susceptibility--The following are vigor indices for rating lodgepole pine and ponderosa pine susceptibility to mountain pine beetle:

1. If growth computes to be less than 50 grams of wood per square meter of foliage, the stand/tree is highly susceptible to beetle buildup.

2. If growth computes to fall between 50 and 100 grams of wood per square meter of foliage, the stand/tree is moderately susceptible to beetle buildup.

3. If growth computes to be greater than 100 grams of wood per square meter of foliage, the stand/tree has low susceptibility to beetle buildup.

2/ Program on magnetic cards is available from R-6 FPM.

B. General Guidelines for Ponderosa Pine

1. Stands of Low-susceptibility

From a practical standpoint, stands with a risk rating of "low" require no immediate management activities. From a silvicultural viewpoint, stand structure is dynamic and even low-risk stands will grow into higher-risk conditions or stagnate and become poor forestry investments.

Low-risk stands can be further classified as precommercial or commercial, depending primarily on tree diameter and local market conditions.

a. Precommercial-size stands present an excellent opportunity for stocking control (precommercial thinning) which not only maintains the low-risk condition but also improves timber growth and yield. In general, stands of this classification average between 4 and 7 inches DBH and will enter higher risk categories prior to attaining merchantable size[3/]. These stands should be thinned at the earliest opportunity. Clearcutting may be a viable opportunity if market conditions are good for pulp logs.

b. Commercial-size stands present three opportunities:

- partial cut (thin)
- clearcut
- hold as an investment until risk is unacceptable or growth rate is unacceptable

The use of stocking level curves as outlined in Silvicultural Examination and Prescription Handbook (FSH 2409.26d, R-6) is recommended.

These stands should be thinned at the earliest opportunity. Clearcutting may be a viable opportunity if market conditions are good for pulp logs.

2. Stands of moderate susceptibility

The principal characteristic of stands in this classification is a stand diameter of 6 inches or larger. Once trees attain a diameter of 6 inches, conditions are favorable for mountain pine beetle brood production. In those cases where stocking is in excess of the maximum stocking level, stand density should be reduced as soon as possible.

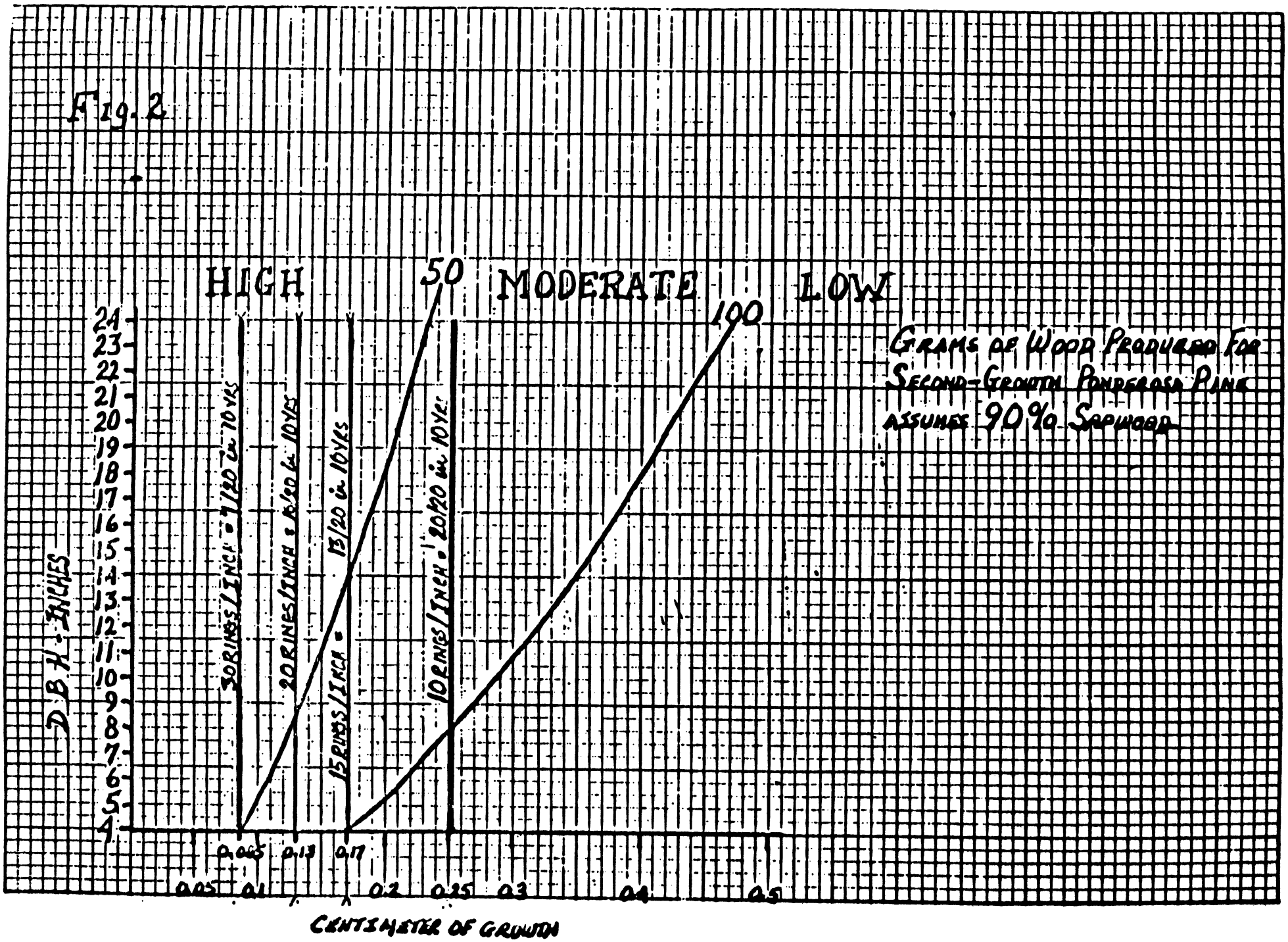
Depending on landowner objectives and market conditions, this can be accomplished through precommerical thinning, commerical thinning, or final harvest. Thinnings should reduce stocking to the recommended level indicated on the appropriate stocking level curve, not to exceed the maximum basal area indicated. Spacing guidelines by basal area are presented in Silvicultural Examination and Prescription Handbook (FSH 2409.26d, R-6).

In those cases where stocking is between maximum and recommended stocking levels (see stocking level curves in R-6 Handbook), plan to harvest at least a portion of the stand when maximum stocking is attained.

3/ Throughout this discussion, merchantable size means a minimum stand diameter of 10 inches.

When considering precommercial thinning or commercial thinning, plan to reduce the basal area below a maximum of 80 sq.ft./acre and preferably below 75 sq.ft./acre. This will promote the survival of the leave trees through an epidemic for 15-20 years, provided the leave trees have a live crown to stem ratio of 40-60%.

If the average live crown to stem ratio is less than 40% or greater than 60%, management options other than thinning should be considered. Trees with crown to stem ratio less than 40% or more than 60% usually do not respond with increase increment growth after being thinned.



Squares to the Inch

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Waring, R. H., K. Newman, and J. Bell.
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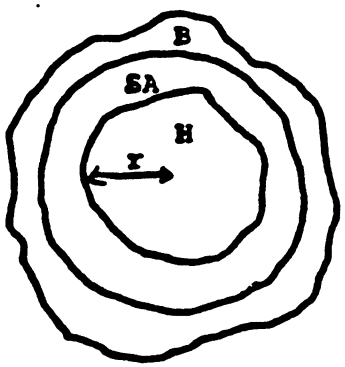
Wright, L. C., A. A. Berryman, and S. Gurusiddaiah.
1979. Host resistance to the fir engraver beetle, *Scolytus ventralis* (Coleoptera:Scolytidae). Canadian Entomologist 111:1255-1262.

APPENDIX B
PROCEDURE FOR INDIVIDUAL TREE RISK RATING

To get a more precise estimate of stand vigor or rate individual trees, you should make direct sapwood area measurements by extracting cores from at least two sides of a tree and measuring the sapwood radius.

The sapwood area (SA) is equal to the cross-sectional area of the stem minus the area of bark (B) and heartwood (H).



The total wood area can be determined from knowledge of tree diameter, assuming bark thickness is a constant proportion of diameter (0.015 DBH for lodgepole).

Thus, total wood area = $\left(\frac{(dbh - (dbh(0.015)(2))}{2}\right)^2$ eq:1

The heartwood area = (total wood radius - sapwood thickness)^2 eq:2

The sapwood area is the difference between total wood area - heartwood area.

Example 1:

A. Given DBH = 20cm
sapwood thickness = 5cm

B. Calculate sapwood area:

1. Substituting into equation 1:

$= 3.14 \left(\frac{(20 - (20)(0.015)(2))}{2}\right) 2$

$= 3.14 \left(\frac{19.4}{2}\right)^2 = 295.6$ cm^2 wood area

*From R. H. Waring, et. al. 1981.

Program Listings

FOR CALCULATING LODGEPOLE,PONDEROSA AND FIR TREE VIGOR VALUES
ON AN HP 41CV CALCULATOR--by T.F. Gregg & R.E. Dolph,Jr.
Forest Pest Management-State &Private Forestry-Pacific Northwest Region 3JAN83

```
          XEQ "VIGORII"
VIGORII
                PRP ""

        01♦LBL "VIGORII"
            02♦LBL a
           03 "VIGORII"
            04 PROMPT
            05 CLRG
            06 CLST
            07 CF 29
        08 "EN:SPECIES="
            09 AVIEW
            10 PSE
      11 "LP:A PP:B FR:C"
            12 PROMPT

            13♦LBL b
            14 FIX 0
            15 CLA
            16 ARCL 00
            17 AVIEW
            18 PSE
            19 CLA
          20 "NEXT PT: "
            21 RCL 20
            22 1
            23 +
            24 ARCL X
            25 AVIEW
            26 PSE
       27 "EN: DBH=INCH"
            28 PROMPT
            29 2.54
            30 *
            31 STO 01
        32 "EN: GROWTH"
            33 "I=CM"
            34 PROMPT
            35 STO 02
            36 CLX
        37 "EN: SAPWD"
            38 "I=CM"
            39 PROMPT
            40 STO 03
            41 CLX
         42 "EN: BA/A"
            43 PROMPT
            44 STO 04
            45 GTO c
```

```
            46♦LBL A
         47 "LODGEPOLE"
       48 "FOLIAGE:FACT"
            49 .15
            50 STO 05
       51 "% SAPWD:FACT"
            52 .70
            53 STO 06
     54 "BARK:THICK:X2"
            55 .03
            56 STO 07
       57 "LOG:FACT 1"
            58 2.4287
            59 STO 08
       60 "LOG:FACT 2"
            61 2.9849
            62 STO 09
            63 "LPP "
            64 GTO 00

            65♦LBL B
         66 "PONDEROSA"
            67 .11
            68 STO 05
            69 .90
            70 STO 06
            71 .11
            72 STO 07
            73 2.4287
            74 STO 08
            75 2.9849
            76 STO 09
            77 "PP "
            78 GTO 00

            79♦LBL C
         80 "DOUG FIR"
            81 1.1
            82 STO 05
            83 .20
            84 STO 06
            85 .13
            86 STO 07
            87 2.5951
            88 STO 08
            89 3.0396
            90 STO 09
            91 "FIR "

            92♦LBL 00
            93 ASTO 00
            94 GTO b
```

Program Listings

```
 95♦LBL c
 96 RCL 03
 97 X=0?
 98 GTO 11
 99 "LONG METHOD"
100 "SAPWOOD AREA"
101 XEQ 01
102 XEQ 02
103 STO 10
104 STO 11
105 XEQ 01
106 RCL 03
107 -
108 X<=0?
109 0
110 XEQ 02
111 ST- 10
112 RCL 10
113 RCL 11
114 /
115 STO 11
116 ST+ 14
117 GTO 12

118♦LBL 11
119 "SHORT METHOD"
120 "SAPWOOD AREA"
121 XEQ 01
122 XEQ 02
123 RCL 06
124 STO 11
125 ST+ 14
126 *
127 STO 10

128♦LBL 12
129 "LEAF AREA"
130 "SQ. M. LEAVES"
131 RCL 10
132 RCL 05
133 *
134 STO 12

135♦LBL 13
136 "TREE GROWTH"
137 "  AND"
138 "BOLE WEIGHT"
139 RCL 01
140 XEQ 03
141 RCL 01
142 RCL 02
143 2
144 *
145 -
146 XEQ 03
147 -
148 RCL 12
149 /
150 1 E3
151 *
152 STO 13
153 GTO d

154♦LBL 01
155 "RADIUS-BARK"
156 "SUBROUTINE"
157 RCL 01
158 RCL 01
159 RCL 07
160 *
161 -
162 2
163 /
164 RTN

165♦LBL 02
166 "AREA:SUBRTINE"
167 X↑2
168 PI
169 *
170 RTN

171♦LBL 03
172 "LOG:SUBRTINE"
173 LN
174 RCL 08
175 *
176 RCL 09
177 -
178 E↑X
179 RTN

180♦LBL d
181 "STATISTICS"
182 RCL 04
183 RCL 13
184 ΣREG 15
185 Σ+
186 ΣREG 21
187 RCL 02
188 RCL 01
189 X↑2
190 Σ+
191 XEQ e
192 STOP
193 GTO 99
```

Program Listings

```
194♦LBL e
195 "OUTPUTS"
196 RCL 13
197 FIX 1
198 CLA
199 ARCL 00
200 XEQ 88
201 STOP

202♦LBL E
203 FIX 1
204 ΣREG 15
205 MEAN
206 CLA

207♦LBL 04
208 "GM:WD/M2/YR"
209 "AVG "
210 XEQ 88
211 RTN
212 CLA

213♦LBL 05
214 "BASAL AREA"
215 "AVG BA/A: "
216 ARCL Y
217 AVIEW
218 STOP
219 CLA

220♦LBL 06
221 "QM DBH: "
222 ΣREG 21
223 MEAN
224 SQRT
225 2.54
226 /
227 ARCL X
228 AVIEW
229 STOP
230 CLA

231♦LBL 07
232 "AVG GTH: "
233 FIX 2
234 ARCL Y
235 "↑CM"
236 AVIEW
237 STOP
238 CLA

239♦LBL 08
240 "AVG SAP: "
241 FIX 0
242 RCL 14
243 100
244 *
245 RCL 20
246 /
247 ARCL X
248 "↑%"
249 AVIEW
250 STOP
251 CLA
252 FIX 0

253♦LBL 09
254 "SAMPLES: "
255 ARCL 20
256 AVIEW
257 STOP

258♦LBL 15
259 "STD DEV"
260 FIX 2
261 ΣREG 15
262 RCL 20
263 1
264 X=Y?
265 GTO 99
266 SDEV
267 CLA
268 "SD GM: "
269 ARCL X
270 AVIEW
271 STOP
272 CLA
273 "SD BA/A: "
274 ARCL Y
275 AVIEW
276 STOP
277 GTO 99

278♦LBL D
279 "% SAPWD OF"
280 "SAMPLE TREE"
281 FIX 1
282 CLA
283 "SAPWD: "
284 100
285 RCL 11
286 *
287 ARCL X
288 "↑%"
289 AVIEW
290 RTN
291 GTO 99
```

Program Listings

```
292*LBL 88
293 "I-GM="
294 ARCL X
295 AVIEW
296 RTN

297*LBL 99
298 GTO b
299 END
```

EXAMPLE OF DATA STORED IN REGISTERS

SIZE 027
FIX 4
PRREG

R00=	"LPP "	
R01=	20.3200	DBH in Centimeters
R02=	0.2500	GROWTH RING THICK.
R03=	4.0000	SAPWOOD THICKNESS
R04=	110.0000	BASAL AREA/ACRE
R05=	0.1500	FOLIAGE FACTOR
R06=	0.7000	%SAPWOOD FACTOR
R07=	0.0300	BARK THICK DOUBLED
R08=	2.4287	LOG FACTOR 1
R09=	2.9849	LOG FACTOR 2
R10=	197.4227	SAPWOOD BASAL AREA
R11=	0.6470	% of SAPWOOD
R12=	29.6134	SQ. METER OF FOLIAGE
R13=	150.4826	ANSWER - VIGOR
R14=	1.3470	% SAPWOOD FOR TREES 1&2
R15=	178.6976	SUM GM WD FOR TREES 1&2
R16=	23441.0949	SUM OF SQUARES
R17=	320.0000	SUM BASAL AREA/ACRE
R18=	56200.0000	SUM OF SQUARES
R19=	22478.2393	SUM OF X&Y
R20=	2.0000	SUM Nº OF SAMPLES
R21=	825.8048	SUM OF SQ. QUAD MEAN
R22=	340976.7838	SUM OF SQUARES
R23=	0.3000	SUM GROWTH FOR TREES
R24=	0.0650	SUM OF YSQ
R25=	123.8707	SUM OF X&Y
R26=	2.0000	SUM Nº OF SAMPLE PLOTS

EXAMPLE RUN FOR TWO PLOTS/TREES

	XEQ "VIGORII"		
VIGORII			Initialize Program
		RUN	Punch R/S Key
EN:SPECIES=			Select TREE SPECIES
LP:A PP:B FR:C			
		XEQ A	Punched Key A - LP
LPP			Displays
NEXT PT: 1			Displays
EN: DBH=INCH			Displays
	8	RUN	Enter 8 inches; Punch R/S
EN: GROWTH=CM			Displays
	.05	RUN	Enter .05cm; Punch R/S
EN: SAPWD=CM			Displays
		RUN	Enter NOTHING; Punch R/S
EN: BA/A			Displays
	210	RUN	Enter 210; Punch R/S
LPP GM=28.2			ANSWER--VIGOR
		XEQ A	Recycle; Punch Key A
LPP			Displays
NEXT PT: 2			"
EN: DBH=INCH			"
	8	RUN	Enter 8 inches; Punch R/S
EN: GROWTH=CM			Displays
	.25	RUN	Enter .25 cm; Punch R/S
EN: SAPWD=CM			Displays
	4	RUN	Enter 4cm; Punch R/S
EN: BA/A			Displays
	110	RUN	Enter 110; Punch R/S
LPP GM=150.5			ANSWER -- VIGOR
		XEQ D	Punch Key D to Know
SAPWD: 64.7%			Percent of Sapwood of Sample Tree Only
		XEQ E	Punch Key E for PLOT AVERAGES --
AVG GM=89.3			GRAMS of WOOD - VIGOR
		RUN	Punch R/S
AVG BA/A: 160.0			BASAL AREA/ACRE
		RUN	Punch R/S
QM DBH: 8.0			QUADRATIC MEAN-DBH
		RUN	Punch R/S
AVG GTH: 0.15CM			GROWTH RING
		RUN	Punch R/S
AVG SAP: 67%			PERCENT SAPWOOD
		RUN	Punch R/S
SAMPLES: 2			Nº of SAMPLES
		RUN	Punch R/S
SD GM: 86.46			STD DEV of GRAMS
		RUN	Punch R/S
SD BA/A: 70.71			STD DEV of BASAL AREA
		RUN	Punch R/S
LPP			Program Recycles
NEXT PT: 3			Back for Next PLOT
EN: DBH=INCH			